(12) UK Patent Application (19) GB (11) 2 349 979 (13) A

(43) Date of A Publication 15.11.2000

(21) Application No 9910799.7

(22) Date of Filing 10.05.1999

(71) Applicant(s)
Cambridge Display Technology Limited
(Incorporated in the United Kingdom)
181A Huntingdon Road, CAMBRIDGE, CB3 0DJ, United Kingdom

(72) Inventor(s)
Jeremy Henley Burroughes
Christopher John Bright

(74) Agent and/or Address for Service
Page White & Farrer
54 Doughty Street, LONDON, WC1N 2LS, United Kingdom

(51) INT CL[7]
H01L 33/00 51/10

(52) UK CL (Edition R)
H1K KEAL K1EA K2R4 K2S20 K5B4 K9N3
U1S S1065 S2285

(56) Documents Cited

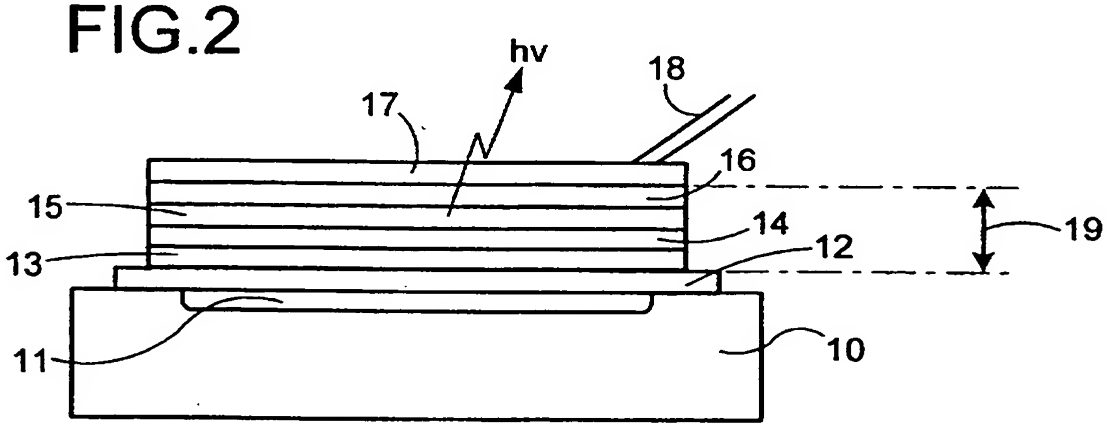
EP 0856896 A1	EP 0801429 A1	EP 0616488 A2
EP 0615401 A1	WO 97/47050 A1	US 5847506 A
US 5714838 A	US 5703436 A	US 5674636 A
US 5616986 A	US 5405710 A	US 3854070 A

(58) Field of Search
UK CL (Edition Q) H1K KEAL KEAM
INT CL[6] H01L
ON LINE,W.P.I.,EPODOC,PAJ

(54) Abstract Title
Light-emitting devices

(57) The light-emitting device comprises an anode electrode 13 for injecting positive charge carriers, a cathode electrode 16 for injecting negative charge carriers and a light-emitting region 15 located between the electrodes. A reflective structure defining a resonant cavity comprises a first metallic reflective layer 12 on one side of the light-emitting region and a second reflective layer 17 on the other side of the light-emitting region, at least one of the reflective layers being partially light-transmissive. The light emitting region comprises a polymer organic material and the reflective layer 12 is made of aluminium. The layer 17 is semi-reflective and is made of gold or aluminium. A multi pixel arrangement of the devices may be used in virtual display spectacles.

FIG.2



GB 2 349 979 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG.1

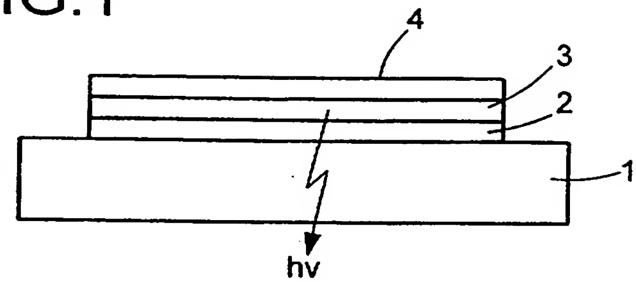


FIG.2

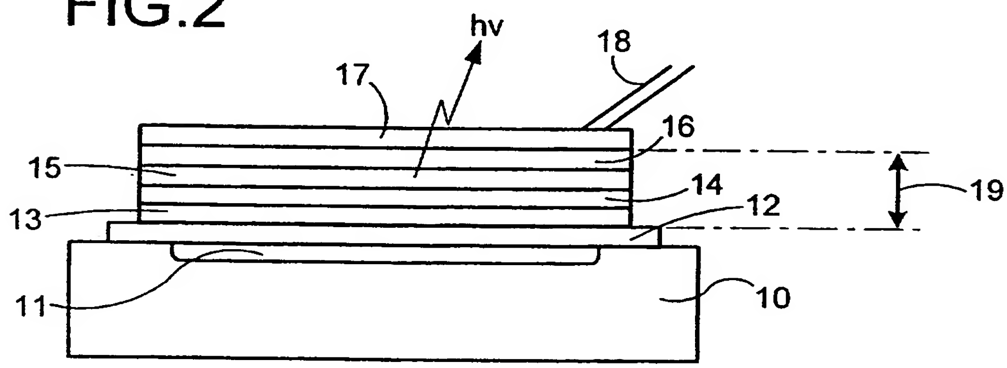
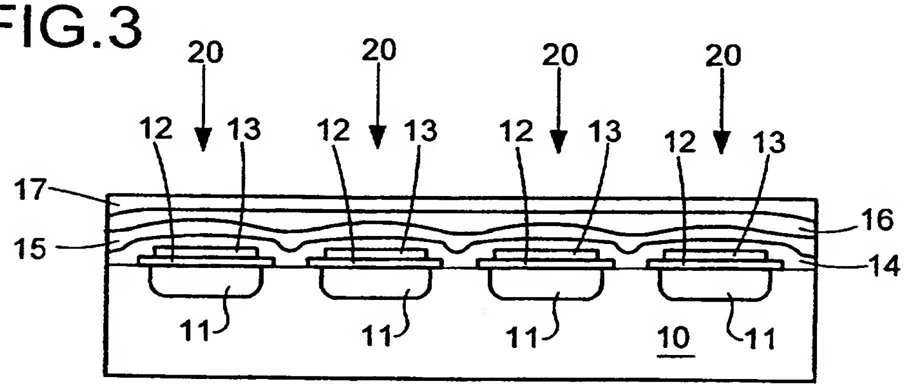


FIG.3



2349979

LIGHT-EMITTING DEVICES

This invention relates to light-emitting devices.

One specific class of light-emitting devices is those that use an organic material for light emission. Light-emitting organic materials are described in PCT/WO90/13148 and US 4,539,507, the contents of both of which are incorporated herein by reference. The basic structure of these devices is a light-emitting organic layer, for instance a film of a poly(p-phenylenevinylene ("PPV"), sandwiched between two electrodes. One of the electrodes (the cathode) injects negative charge carriers (electrons) and the other electrode (the anode) injects positive charge carriers (holes). The electrons and holes combine in the organic layer generating photons. In PCT/WO90/13148 the organic light-emitting material is a polymer. In US 4,539,507 the organic light-emitting material is of the class known as small molecule materials, such as (8-hydroxyquinoline)aluminium ("Alq3"). In a practical device one of the electrodes is typically transparent, to allow the photons to escape the device.

Figure 1 shows the typical cross-sectional structure of an organic light-emitting device ("OLED"). The OLED is typically fabricated on a glass or plastic substrate 1 coated with a transparent first electrode 2 such as indium-tin-oxide ("ITO"). Such coated substrates are commercially available. This ITO-coated substrate is covered with at least a layer of a thin film of an electroluminescent organic material 3 and a final layer forming a second electrode 4, which is typically a metal or alloy. Other layers can be added to the device, for example to improve charge transport between the electrodes and the electroluminescent material.

In many applications a display device has a number of individually controllable light-emitting areas (pixels) which could be of the same shape – for example square or rectangular – or of different shapes to suit specific applications. To drive a multi-pixel device connections must be made to the pixels so that the pixels can

be addressed individually. This can be done by a passive matrix addressing scheme, in which row electrodes are provided on one side of the display and column electrodes are provided on the other side of the display, but in this scheme only one row or column can be addressed at a time. An alternative addressing method involves providing contacts to the pixels individually, but this has generally required precise fabrication techniques which are difficult to achieve. One approach is to use an active matrix drive scheme. Typically the active matrix drive electronics is fabricated from amorphous or poly silicon on glass or plastic with a connection to the ITO anode. Hence the cathode is usually opaque as light is transmitted through the substrate. Alternatively the drive electronics can be built on silicon (or GaAs), but in this case the substrate will be opaque. This requires the device to emit from the other face or the structure will need to be inverted.

OLEDs generally have a relatively broad emission spectrum, whereas narrower emission spectra are desired for many applications.

According to one aspect of the present invention there is provided a light-emitting device comprising: a light-emitting structure comprising an anode electrode for injecting positive charge carriers, a cathode electrode for injecting negative charge carriers and a light-emitting region located between the electrodes; and a reflective structure defining a resonant cavity about the light-emitting region and comprising a first metallic reflective layer on one side of the light-emitting region and a second reflective layer on the other side of the light-emitting region, at least one of the reflective layers being partially light-transmissive.

The said one of the reflective layers is preferably the second reflective layer, but could be the first reflective layer. The other of the reflective layers could be partially reflective (and then preferably partially light-transmissive) or fully reflective.

The anode electrode may be light transmissive and is preferably located between the first and second reflective layers. The cathode electrode may be light

transmissive and is preferably located between the first and second reflective layers. The second reflective layer may be located adjacent the anode electrode or the cathode electrode.

There may be a semiconductor structure adjacent the first reflective layer for supplying charge carriers through the second reflective layer to the light-emitting structure.

According to a second aspect of the present invention there is provided a light-emitting device formed on a semiconductor substrate having circuitry therein for supplying charge carriers to the light-emitting device, the device comprising: a light-emitting structure comprising an anode electrode for injecting positive charge carriers, a cathode electrode for injecting negative charge carriers and a light-emitting region located between the electrodes; and a metallic layer located between the semiconductor substrate and one of the electrodes.

The semiconductor structure/substrate may comprise silicon. The semiconductor structure may include one contact region for supplying positive or negative charge carriers to the light-emitting structure. More preferably the semiconductor structure includes two or more such contact regions for independently supplying charge carriers to individual separate regions (pixels) of the light-emitting structure. In the light-emitting structure one or both of the electrode regions may be patterned into individual areas each corresponding to a respective pixel.

The metallic layer is preferably adjacent the semiconductor substrate and/or one of the electrodes. One or both of the electrodes is preferably light transmissive.

The metallic layer is suitably reflective, and preferably the device also has a second reflective layer defining with the metallic layer a resonant cavity about the light-emitting region. The second reflective layer (which may be metallic) is suitably partially light-transmissive.

According to a third aspect of the present invention there is provided a method for forming a light-emitting device on a semiconductor substrate having circuitry therein for supplying charge carriers to the light-emitting device, the method comprising: depositing a metallic layer in contact with the substrate; depositing a first electrode for injecting charge carriers of a first type in contact with the metallic layer; depositing a region of light-emitting material over the first electrode; and depositing a second electrode for injecting charge carriers of a second type over the region of light-emitting material. The method may also comprise the step of depositing a reflective layer over the second electrode.

Preferred materials for parts of the device(s) will now be described.

The anode electrode preferably has relatively high work function – e.g. greater than 4.0, 4.3 or 4.5eV. The anode electrode could be formed, for example, of indium-tin oxide, tin oxide nickel oxide or another transparent conducting oxide or other suitable material. The conductivity of the anode does not have to be as good as that of ITO and may be several orders of magnitude less. The cathode electrode preferably has relatively low work function – e.g. less than 3.5, 3.2 or 3.0eV. The cathode electrode could be formed, for example, of a metal such as Li, Ca, Mg, Cs, Ba Yb or Sm or an oxide or fluoride thereof.

The or each metallic layer is suitably an aluminium layer. The or each metallic layer suitably comprises aluminium, preferably principally comprises aluminium and most preferably is substantially wholly composed of aluminium. Another metal could be used, and may be equally or more suitable to maximise reflectivity.

The light-emitting region suitably comprises a light-emitting organic and/or polymer material. The light-emitting material is preferably a semiconductive and/or conjugated polymer material. Alternatively the light-emitting material could be of other types, for example sublimed small molecule films or inorganic light-emitting material. The or each organic light-emitting material may comprise one or more individual organic materials, suitably polymers, preferably fully or partially

conjugated polymers. Example materials include one or more of the following in any combination: poly(p-phenylenevinylene) ("PPV"), poly(2-methoxy-5(2'-ethyl)hexyloxyphenylenevinylene) ("MEH-PPV"), one or more PPV-derivatives (e.g. di-alkoxy or di-alkyl derivatives), polyfluorenes and/or co-polymers incorporating polyfluorene segments, PPVs and related co-polymers, poly(2,7-(9,9-di-n-octylfluorene)-(1,4-phenylene-((4-secbutylphenyl)imino)-1,4-phenylene)) ("TFB"), poly(2,7-(9,9-di-n-octylfluorene) - (1,4-phenylene-((4-methylphenyl)imino)-1,4-phenylene-((4 - methylphenyl)imino) - 1,4-phenylene)) ("PFM"), poly(2,7 - (9,9 - di-n-octylfluorene) - (1,4-phenylene-((4-methoxyphenyl)imino)-1,4-phenylene-((4-methoxyphenyl)imino)-1,4-phenylene)) ("PFMO"), poly (2,7-(9,9-di-n-octylfluorene) ("F8") or (2,7-(9,9-di-n-octylfluorene)-3,6-Benzothiadiazole) ("F8BT"). Alternative materials include small molecule materials such as Alq3.

One or more charge-transport layers may be provided between the light-emitting region and one or both of the electrodes. The or each charge transport layer may suitably comprise one or more polymers such as polystyrene sulphonic acid doped polyethylene dioxythiophene ("PEDOT-PSS"), poly(2,7-(9,9-di-n-octylfluorene)-(1,4-phenylene-(4-imino(benzoic acid))-1,4-phenylene-(4-imino(benzoic acid))-1,4-phenylene)) ("BFA"), polyaniline and PPV.

The present invention will now be described by way of example with reference to the accompanying drawings, in which:

figure 2 is a cross-section of a light-emitting device on a substrate; and

figure 3 is a cross-section of part of a multi-pixel light-emitting device on a substrate.

The device of figure 2 is formed on a silicon substrate 10. An organic light-emitting device formed of layers 13, 14, 15, 16 is located on the substrate. Between the device and the substrate lies a reflective metallic layer 12, and over the device is a thin partially reflective metallic layer 17. These two layers provide a convenient means of defining a resonant cavity about the OLED which allows the emission spectrum of the device to be narrowed. Furthermore, the layer 12 acts

as an interface between the OLED and the substrate 10, whose material properties are compatible with both the OLED and the silicon substrate. With the layer 12 in place circuitry formed by circuit elements such as transistors and resistors in the silicon substrate can be electrically coupled to OLED to allow the OLED to be driven and/or switched by circuitry in the substrate itself.

The formation of the device of figure 2 will now be described in more detail.

The substrate 10 is formed from a silicon wafer in which circuit elements have been formed in the conventional way. The circuitry in the substrate terminates in an electrically conductive region 11. The layer 12 is formed of a metal such as aluminium, which could be deposited by any suitable process, such as sputtering, evaporation or chemical vapour deposition. The deposition process must be compatible with the silicon substrate. The thickness of the layer 12 could be around 100nm.

The anode electrode layer 13 is deposited over the reflective layer 12. The layer 13 is formed of ITO. The thickness of the ITO layer is suitably around 2 to 250nm and the ITO suitably has a sheet resistance of between 2 and 10000 $\Omega/\square$. The ITO layer could be deposited by evaporation or sputtering. Instead of ITO other conductive materials such as doped tin oxide (TO), or nickel oxide could be used for the anode electrode. It is preferred that the material of the anode has a relatively high work function – for instance greater than 4.0, 4.3 or 4.5 eV – to assist hole injection into the light-emitting layer of the OLED.

To further assist hole injection a hole transport layer 14 is deposited over the anode layer 13. The hole transport layer is formed from a solution containing PEDOT:PSS with a ratio of PEDOT to PSS of around 1 to 5. The thickness of the hole transport layer is suitably in the range from 10 to 200nm, preferably around 40nm. The hole transport layer is spin-coated from solution and then baked typically at 200°C for 1 hour in a nitrogen environment. Other materials such as

polyaniline could be used for the hole transport layer, or the layer could be omitted although this may influence long term device performance.

Electroluminescent layer 15 is deposited over the hole transport layer. The electroluminescent layer could be formed of, for example, a blend comprising 20% TFB in 5BTF8. This can be is coated over the hole transport layer by spin-coating, typically to a thickness of around 70nm. The term 5BTF8 refers to poly (2,7-(9,9-di-*n*-octylfluorene) ("F8") doped with 5% poly-(2,7-(9,9-di-*n*-octylfluorene)-3,6-benzothiadiazole) ("F8BT"). Other polymer organic light-emitting materials or other types of light-emitting materials (e.g. small molecule organic materials) could be used for the layer 15.

Over the electroluminescent layer a cathode electrode layer 16 is deposited. The cathode layer is formed of a dielectric electron injecting material such as CsF or LiF. The material used for the layer 16 is preferably fully or partially transparent and preferably has a relatively low work function – for instance less than 3.5, 3.2 or 3.0 eV – to assist electron injection into the light-emitting layer of the OLED. The thickness of the layer 16 could be in the range from 0.3 to 10nm, preferably around 2nm. The layer could be deposited by evaporation.

The layer 17 is formed so as to be semi-reflective. This may be done by careful control of the layer's thickness. For example, if the layer is of gold or aluminium then its thickness is preferably less than 20nm, more preferably in the range from 5nm to 20nm. It is preferred that the layer is electrically conductive, since it can then assist in giving uniform charge distribution over the cathode electrode layer 16.

A cathode contact connection 18 is made to the layer 16 or 17. At least the layers 12-17 of the device are preferably encapsulated (for instance in epoxy resin) for environmental protection.

To operate the device the circuitry of the silicon substrate is configured to apply a suitable voltage between the anode and cathode electrodes to cause the light-emitting layer 14 to emit light.

At the surface of the silicon substrate is a contact region 11. This could be a region of aluminium or other conductor embedded in or coated on the silicon, or could be a region of p- or n-doped semiconductive silicon. The layers 12 to 14 have been selected to enhance the performance of the light-emitting device when driven from a silicon substrate with which it is in direct contact. The aluminium layer 12 is metallic and forms an ohmic contact with the contact region 11 and with the ITO layer 13. The aluminium layer serves the additional function of acting as one mirror of an optical cavity, as explained below. Also, the aluminium layer will reduce the effect of the resistance of the ITO layer allowing other oxides with higher resistivities to be used. The ITO layer 13 has a relatively low work function so that positive charge carriers can be efficiently injected from it into the light-emitting layer. Since the ITO layer is transparent light emitted from the emitting layer can reach the mirror 11 of the cavity. The ITO also serves as an optical spacer between the mirror and the emitting layer. It will help to protect the mirror surface from chemical attack from the hole transport layer which may be acidic or alkaline. The PEDOT:PSS layer 14 provides an intermediate energy level that further enhances charge carrier injection into the emitting layer.

The contact region 11 could be replaced or supplemented by a planarisation layer on top of the silicon substrate.

The aluminium layer 12 could be omitted, and a direct contact made between the ITO layer 13 and the contact region 11. However, this might cause poorer device performance, and if the upper surface of the silicon substrate were not reflective then the cavity effect described below would be lost.

The device of figure 2 is configured with its anode driven from the silicon substrate. Alternatively, a device could be built with its cathode driven from the

silicon substrate. That may call for alteration of the circuitry of the silicon substrate for supply of negative rather than positive charge carriers.

An optical cavity is formed between the surfaces of the reflective layers 12 and 17 that face towards the OLED. The cavity gap is the distance between these surfaces, as illustrated by arrow 19. The cavity acts as a Fabry-Perot resonator, which concentrates emission from the OLED at the resonance wavelengths of the cavity and can even enhance emission from the OLED compared to its free-space emission due to waveguide effects perpendicular to the emission direction (see J Grüner *et al.*, J Appl. Phys. 80, 207 (1996)). The resonance wavelengths λ_{res} of the cavity are given by:

$$\lambda_{res} = \frac{2L_{eff}}{q}$$

where q is an integer and L_{eff} is the effective length of the cavity which is in turn given by:

$$L_{eff} = L_{phase\_change} + \sum n \cdot L_{layer\_thickness}$$

where L_{phase_change} is the effective length increase due to reflection of light from the reflective surfaces and n is the refractive index of each layer between the reflective surfaces and $L_{layer\_thickness}$ is the thickness of the respective layer. Therefore, by forming the device so that the thicknesses of the layers of the OLED define a desired effective cavity length the emission of the OLED can be concentrated at a desired wavelength. The ITO layer could be easily deposited to a desired thickness to set the resonance of the cavity. The thickness of the hole transport material can also be easily optimised, the ratio of ITO and hole transport material will be chosen to minimise absorbtion in the structure. This can greatly enhance the performance of the device in applications where spectrally narrow emission is desired. It is preferred that integer q is low (e.g. 1, 2, 3, 4 or 5) because absorption in the cavity is greater for thicker cavities, reducing the device's efficiency.

Instead of being formed by a single layer, one or both of the mirrors of the cavity could be dielectric stack mirrors formed by alternating layers of different refractive indices.

An additional transparent or semi-transparent conductive layer may be introduced between layers 16 and 17 or over layer 17 to assist in lowering the electrical resistivity of the cathode structure.

The charge transport layer 14 could be omitted or additional charge transport layers could be provided between the anode and/or the cathode and the light-emitting region to assist charge transport between the respective electrode and the light-emitting layer.

The silicon substrate could be omitted, and conductors applied to the layers 12 and/or 13 and the layers 16 and/or 17 to allow a voltage to be applied across the device. If the layer 12 were semi-transparent then the cavity effect could be retained, but light emitted from both major faces of the device, or if the layer 17 were fully reflective only from the anode face.

Figure 3 shows a multi-pixel version of the light-emissive device of figure 2. Like components are numbered in figure 3 as for figure 2. The pixels 20 are defined by an additional step of masking and etching the metallic layer 12 and the ITO layer 13 to electrically isolate the anodes of each pixel. The remaining layers could be common to all the pixels or also patterned, with the polymer layers being deposited by a selective process such as ink-jet printing. The pixels could be of the same or different shapes.

The device is suitably a small or micro display – e.g. around 10mm x 10mm in size – but could be larger or smaller. Such displays could be used for, for instance, high resolution virtual display spectacles.

The principles described above could be applied to other types of organic or inorganic display devices. One specific alternative example is the class of display devices that use "small molecule" organic materials for light emission.

The applicant draws attention to the fact that the present invention may include any feature or combination of features disclosed herein either implicitly or explicitly or any generalisation thereof, without limitation to the scope of any of the present claims. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

CLAIMS

1. A light-emitting device comprising:

a light-emitting structure comprising an anode electrode for injecting positive charge carriers, a cathode electrode for injecting negative charge carriers and a light-emitting region located between the electrodes; and

a reflective structure defining a resonant cavity about the light-emitting region and comprising a first metallic reflective layer on one side of the light-emitting region and a second reflective layer on the other side of the light-emitting region, at least one of the reflective layers being partially light-transmissive.

2. A light-emitting device as claimed in claim 1, wherein the light-emitting region comprises a light-emitting polymer material.

3. A light-emitting device as claimed in claim 1 or 2, wherein the light-emitting region comprises a light-emitting organic material.

4. A light-emitting device as claimed in any preceding claim, wherein the anode electrode is light transmissive and located between the first and second reflective layers.

5. A light-emitting device as claimed in any preceding claim, wherein the cathode electrode is light transmissive and located between the first and second reflective layers.

6. A light-emitting device as claimed in any preceding claim, wherein the second reflective layer is adjacent the anode electrode or the cathode electrode.

7. A light-emitting device as claimed in any preceding claim, wherein the second reflective layer is partially light-transmissive.

8. A light-emitting device as claimed in claim 7, wherein the thickness of the second reflective layer is less than 20nm.

9. A light-emitting device as claimed in any preceding claim, wherein the second reflective layer is metallic.

10. A light-emitting device as claimed in any preceding claim, having a semiconductor structure adjacent the first reflective layer for supplying charge carriers through the second reflective layer to the light-emitting structure.

11. A light-emitting device formed on a semiconductor substrate having circuitry therein for supplying charge carriers to the light-emitting device, the device comprising:

a light-emitting structure comprising an anode electrode for injecting positive charge carriers, a cathode electrode for injecting negative charge carriers and a light-emitting region located between the electrodes; and

a metallic layer located between the semiconductor substrate and one of the electrodes.

12. A light-emitting device as claimed in claim 11, wherein the light-emitting region comprises a light-emitting polymer material.

13. A light-emitting device as claimed in claim 11 or 12, wherein the light-emitting region comprises a light-emitting organic material.

14. A light-emitting device as claimed in any of claims 11 to 13, wherein the metallic layer is adjacent the semiconductor substrate.

15. A light-emitting device as claimed in any of claims 11 to 14, wherein the metallic layer is adjacent the anode electrode or the cathode electrode.

16. A light-emitting device as claimed in any of claims 11 to 15, wherein the anode electrode and the cathode electrode are light transmissive.

17. A light-emitting device as claimed in claim 16, wherein the metallic layer is reflective, the device having a second reflective layer defining with the metallic layer a resonant cavity about the light-emitting region.

18. A light-emitting device as claimed in claim 17, wherein the second reflective layer is partially light-transmissive.

19. A light-emitting device as claimed in claim 18, wherein the thickness of the second reflective layer is less than 70nm.

20. A light-emitting device as claimed in any of claims 17 to 19, wherein the second reflective layer is metallic.

21. A method for forming a light-emitting device on a semiconductor substrate having circuitry therein for supplying charge carriers to the light-emitting device, the method comprising:

depositing a metallic layer in contact with the substrate;

depositing a first electrode for injecting charge carriers of a first type in contact with the metallic layer ;

depositing a region of light-emitting material over the first electrode; and

depositing a second electrode for injecting charge carriers of a second type over the region of light-emitting material.

22. A method as claimed in claim 22, comprising the step of depositing a reflective layer over the second electrode.

23. A light-emitting device substantially as herein described with reference to figures 2 and 3 of the accompanying drawings.

24. A method of forming a light-emitting device substantially as herein described with reference to figures 2 and 3 of the accompanying drawings.

Application No:	GB 9910799.7	**Examiner:**	COLIN STONE
Claims searched:	11-22	**Date of search:**	24 January 2000

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H1K(KEAL,KEAM)

Int Cl (Ed.7): H01L

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0856896 A1	I.B.M. (See metal layer 64,Fig.3)	11
X	WO 97/47050 A1	I.B.M. (See metallic layer 81.1,table 3,page 30)	11,21
X	US 5847506	HITACHI (See layer 2,Fig.1 and col.5 lines 39,40)	11,21
X	US5714838	I.B.M. (See metal layer 24,Fig.2)	11,21
X	US 5703436	TRUSTEES OF PRINCETON UNIV.(See metal layer 38,Fig.2C)	11,21

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

The Patent Office

INVESTOR IN PEOPLE

Application No:	GB 9910799.7	**Examiner:**	C.D.Stone
Claims searched:	1-10	**Date of search:**	9 August 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H1K(KEAL,KEAM)

Int Cl (Ed.6): H01L

Other: ON LINE,W.P.I.,EPODOC,PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0801429 A1	LUCENT TECHNOLOGIES	1 at least
X	EP 0616488 A2	HITACHI	"
X	EP 0615401 A1	HITACHI	"
X	US 5674636	DODABALAPUR	"
X	US 5616986	UNIVERSITY OF GEORGIA	"
X	US 5405710	A.T.&T.	"
X	US 3854070	VLASENKO ET AL.	"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		